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GASEOUS DISCHARGE DEVICE

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FIG. 1

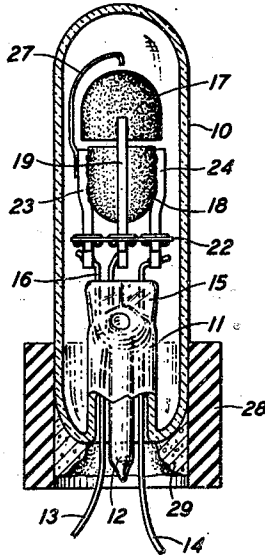


FIG. 2

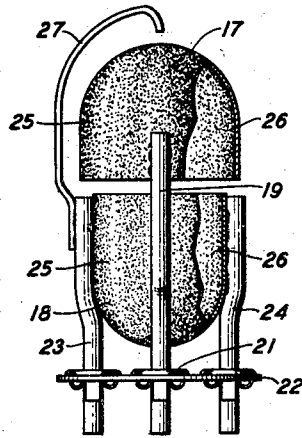


FIG. 3

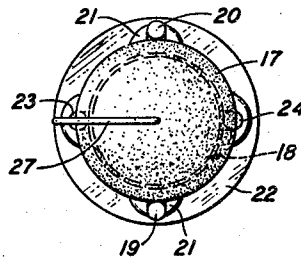
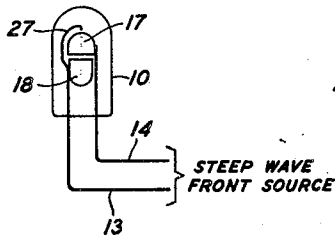


FIG. 4



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GASEOUS DISCHARGE DEVICE

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12 Claims. (Cl. 176—122)

This invention relates to electric gaseous discharge devices and a method of activation therefor and more particularly to devices of the cathode glow type.

In low voltage glow discharge devices operating as a light or signal source, the cathode is usually coated with a low work function substance, such as barium and strontium or the like, which is initially prepared by utilizing the compound form of the substance as the cathode coating. This is activated to decompose the compound to the emissive metal. When such a coating is applied to a hollow cathode placed close to the end of a small glass enclosure to obtain the greatest uniformity as a light source and an anode is positioned at the rear of the cathode, considerable difficulty results due to incomplete activation of the cathode coating which causes the appearance of dark objectionable blotches at the portion of the cathode furthest removed from the anode, thereby rendering the cathode low in efficiency as a light source when employed in an indicating system.

An object of this invention is to produce a highly uniform glow discharge device.

Another object of the invention is to facilitate the complete activation of the cathode.

A further object of the invention relates to a method of producing a uniformly activated surface on a cathode which contains an area normally unaffected by the activating discharge.

In accordance with one aspect of this invention, two similar dome-shaped electrodes are mounted axially in opposed relation with their bases in parallelly adjacent planes and are supported in a vessel with the upper electrode close to the dome end of a vessel to produce an efficient light or signal source. The electrodes are coated on their outer surfaces with an electron emitting material and the inner surfaces are coated with an insulating material to confine the glow to the useful cathode surface. The electrodes are held in suitable spaced relation by pairs of supports anchored in a spacing insulator disc adjacent a stem forming a sealing point for the conductors of the electrodes. This arrangement forms a compact unit assembly for the electrodes to utilize the whole area of the cathode as a source of light which is projected through the adjacent end of the vessel.

In order to facilitate the activation of the cathode and also to overcome the objectionable dark spots on the cathode apex, a wire probe extension is secured to the anode and extends toward the center of the cathode. When an ac-

tivating discharge is produced between the cathode and anode, decomposition of the coating occurs simultaneously between the adjacent cathode-anode surfaces and the probe-cathode surfaces to completely activate the whole cathode area and increase the efficiency of the glow discharge device.

Another particular advantage of the probe arrangement in the operation of the device is that the anode-cathode fall of potential over the entire cathode surface may be held substantially constant, thereby enabling the cathode to glow uniformly, so that it is not necessary to increase the current rating of the electrodes in order to maintain the whole area of the cathode emitting to ionize the adjacent gaseous layer in the vessel.

These and other features of the invention will be more clearly understood from the following description taken in connection with the accompanying drawing:

Fig. 1 is a view in elevation partly in cross-section of a gaseous discharge device of this invention showing the construction and mounting of the main and probe electrodes in the vessel;

Fig. 2 is an enlarged view of the electrode mount or unit with a portion of the electrodes broken away to illustrate the inner coating thereon;

Fig. 3 is a plan view of the mount shown in Fig. 2; and

Fig. 4 illustrates a circuit arrangement for activating a type of device as shown in Fig. 1.

Referring to Figs. 1, 2 and 3, of the drawing, a small diameter tubular glass vessel 10 provided with a reentrant stem 11 having an exhaust tubulation 12 within the stem forms an enclosure for an electrode unit of the device of this invention. A pair of leading-in conductors 13 and 14 are sealed in a press 15 of the stem and a short stub wire 16 is also sealed in the press 15. A dome-shaped hollow cup electrode 17, which functions as the cathode of the device, is mounted in axial position in the vessel with the dome surface adjacent the top of the vessel and a similar dome-shaped electrode or anode 18 is mounted below the cathode in axial relation with their bases in juxtaposed relation and separated by a gap of minute proportions. The cathode blocks the open cavity of the anode 18 and is supported by a pair of rods 19 and 20 which are attached near the edge of the cup and extend downwardly through eyelet openings 21 in a mica disc 22. The cup-shaped anode 18 is similarly supported by a pair of rods 23 and 24 attached to the anode at posi-

tions 90 degrees with respect to the cathode supports and these rods extend through similar eyelet openings in the disc 22. The projecting ends of the rods extending through the mica disc are connected to the conductors and stub wire extending from the press. As shown in Fig. 1, the cathode is connected to leading-in conductor 13 while the anode is connected to leading-in conductor 14 and the auxiliary support 16 is attached to the anode support 23 to increase the rigidity of the mounting of the unit.

In order to meet the stringent restrictions of the illustrated device of this invention, with regard to breakdown and sustaining voltages, in the operation of the device, the dome-shaped electrodes were found to provide the required surface area for the electrodes in the limited configuration of the vessel which is approximately $\frac{1}{2}$ inch in diameter and $1\frac{3}{4}$ inches long so that the dimensions shown in Fig. 1 represent a device approximately twice the size of an actual lamp. The anode 18 has a diameter of .266 inch while the length thereof is .288 inch. The cathode has a diameter of .296 inch and a length of .257 inch. The gap between the two electrodes is maintained at .020 inch $\pm$.005 inch so that a discharge may be maintained at a relatively low voltage of about 60 volts. The vessel 10 is filled with a suitable ionizable gas such as a mixture of 99 per cent neon and 1 per cent argon at a pressure of the order of 40 millimeters of mercury.

In order to attain a low voltage discharge between the electrodes, the external surfaces of the electrodes are coated with an emissive substance 25 of low work function and the internal surfaces of the electrodes are coated with a non-emissive substance 26 to confine the glow discharge to the useful surfaces of the electrodes. The emissive coating 25 of the electrodes is preferably produced by spraying or otherwise coating the outer surfaces of the cathode 17 and the anode 18 with a mixture of alkaline earth metal compounds, such as barium and strontium carbonates or other similar compounds together with a suitable binder, such as nitrocellulose and amyl acetate. The inner surfaces of the electrodes are coated with powdered aluminum in the same binder material as mentioned above and this coating is calorized to fix the coating to the inner surface and convert some of the aluminum to aluminum oxide.

In order to render the coating on the external surface of the cathode active, it is necessary to convert the alkaline earth compounds of the coating to active metal to increase the efficiency of the glow produced by the discharge in the vessel and in preliminary developments of the device it was discovered that adequate activation occurred adjacent the edges of the electrodes but the central area of the cathode was unactivated and resulted in the appearance of dark objectionable blotches on the cathode surface which considerably reduced the uniformity of the glow as a light source. This difficulty arises from the difference in the potential drops between the anode and different portions of the cathode as the cathode area extends away from the anode. If the current supplied to the electrodes is increased to offset the difference in potential drop then the area of the cathode adjacent to the anode is overloaded thereby causing arcing and deterioration of the active material of the cathode. This is overcome in accordance with this invention by affixing a probe electrode or wire 27 to the support 23 of the anode and extending the probe

upwardly along the surface of the cathode 17 and curving the probe wire towards the central surface of the cathode or apex of the dome to space the free end thereof from the cathode surface a distance of approximately $\frac{1}{4}$ inch.

In the manufacture of the lamp, after the unit is mounted in the vessel, the carbonate coating is decomposed to oxides and the vessel is exhausted and sealed off at the tubulation 12 after the gaseous filling is injected. The next step is the activation of the oxide coating on the external surfaces of the electrodes and this is produced by applying a high frequency steep wave front source of energy to the conductors 13 and 14 of the device to reduce the alkaline earth oxides on the cathode and anode surfaces to active metal, such as barium. The alternating character of the discharge rapidly bombards the particles of oxides on the surfaces of the electrodes whereby the discharge across the gap of the two electrodes conditions the lower surface of the cathode while the discharge across the gap between the probe electrode 27 and the upper cathode surface completes the activation of the cathode and eliminates the appearance of blotches or spots which are inert during the operation of the device. This arrangement facilitates the simultaneous activation of the cathode by the discharge between the anode-cathode surfaces and the probe-cathode surfaces so that the complete external area of the cathode is activated to serve as a source of copious electron emission.

Although both electrodes are coated with the electron emissive material to facilitate the lowering of the breakdown voltage between the two electrodes, it is evident that when the electrodes are connected in a signaling circuit to a direct current source of 60 volts, the cathode primarily produces the source of light through the end of the vessel, so that it is essential to completely activate the cathode surface. The condition of the anode surface is not so important since this electrode does not contribute to the glow phenomena in the device when direct current is employed. Furthermore, the position of the probe electrode 27 in relation to the cathode surface facilitates the operation of the device, since it enables the entire cathode surface to bear substantially the same anode-cathode fall of potential, thereby allowing the glow discharge to cover the whole cathode surface. On the other hand if the probe were removed, it would be necessary to substantially increase the current between the electrodes in order to sustain the glow discharge over the whole area of the cathode. The increase in current may be as much as 200 per cent, so that it is evident that the inclusion of the probe electrode in the device not only facilitates the activation of the cathode but also materially enhances the operating characteristics of the device in operation. Consequently, in the operation of the device of this invention the complete and uniform glow condition of the cathode may be sustained at a voltage determined by the geometry of the electrode assembly. The glow conditions and voltage requirements are, of course, variable with different electrode geometries but according to the teaching of this invention, it is possible to attain maximum glow efficiency with minimum sustaining voltage for the discharge.

The activated coating on the electrodes of the device is further processed by a stabilizing treatment in which an alternating current of approximately 100 per cent overload is applied to the

electrodes for a period of 20 to 45 minutes to equalize the activity over the whole surface of the electrodes.

The device shown in Fig. 1 may be completed for mounting purposes by affixing an insulating sleeve 28 to the stem end of the device by a suitable cement 29 so that the lamp may be mounted in a suitable holder and the conductors connected to the operating circuit of the device.

While the invention has been disclosed in a specific embodiment as shown, it is, of course understood, that various modifications may be made in the structural features and configurations of the unit without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In the manufacture of a glow discharge device having a pair of electrodes of large surface area mounted in cooperating relation with long path areas between the edge of one electrode and the center of the other electrode with a surface layer of low work function material thereon, the method of activating the surface material which comprises initiating a high frequency discharge between said electrodes to activate a portion of the material of one electrode adjacent the other electrode in which the fall of potential limits the spread of the discharge, and completing the activation by applying a high frequency discharge between the central area of the partially activated electrode and an extension of the other electrode arranged close to said central area whereby the difference in fall of potential along different portions of said activated electrode is overcome.

2. In the manufacture of a glow discharge device having a pair of electrodes of large surface area mounted in cooperating relation with long path areas between the edge of one electrode and the center of the other electrode with a surface layer of low work function material thereon, the method of activating the surface material which comprises initiating a high frequency discharge between said electrodes to activate a portion of the material of one electrode adjacent the other electrode in which the fall of potential limits the spread of the discharge, and completing the activation by applying a high frequency discharge between the central area of the partially activated electrode and an extension of the other electrode arranged close to said central area whereby the difference in fall of potential along different portions of said activated electrode is overcome, and stabilizing the activated material on said electrode to simulate a diffused glow source of light.

3. In the manufacture of a glow discharge device having a pair of electrodes of large surface area mounted in cooperating relation with long path areas between the edge of one electrode and the center of the other electrode with a surface layer of low work function material thereon, the method of activating the surface material which comprises initiating a high frequency discharge of steep wave front between said electrodes to activate a portion of the material of one electrode adjacent the other electrode in which the fall of potential limits the spread of the discharge, and completing the activation by applying a high frequency discharge of steep wave front between the central area of the partially activated electrode and an extension of the other electrode arranged close to said central area whereby the difference in fall of po-

tential along different portions of said activated electrode is overcome.

4. The method of producing a glow discharge device which comprises coating hemispherical hollow electrodes with alkaline earth compounds, mounting said electrodes in a vessel in axial relation, decomposing said compound to oxides, reducing the oxides on one of said electrodes by a high frequency discharge from the edge of one electrode to a portion of the outer surface of the other electrode adjacent said edge, and simultaneously producing a similar discharge from the central zone of said other electrode and an extension from said one electrode.

5. The method of producing a glow discharge device which consists in coating substantially hemispherical hollow electrodes with barium and strontium compounds, mounting said electrodes in a small diameter vessel with their bases closely spaced and with the curved surfaces thereof widely spaced in axial relation, affixing a wire element to the periphery of one electrode, extending said wire toward the apex of the other electrode to simulate an electric field equivalent to the field adjacent the bases of said electrodes, decomposing said compounds to oxides, injecting a gaseous filling at low pressure in said vessel, sealing said vessel, and reducing the oxides of the coating on one of said electrode by a simultaneous high frequency discharge between said electrodes and said wire element and one electrode.

6. A glow discharge device comprising a vessel having a stem, a gaseous medium therein, a dome-shaped cathode adjacent the end of said vessel away from said stem, an anode coaxial therewith and positioned between said cathode and said stem, said cathode having an electron emitting coating on the surface directed toward the end of said vessel, and conductive means extending from said anode to the axial area of said cathode whereby the potential drop between all points of the cathode and anode is constant and the sustaining voltage for rendering the complete emitting area of said cathode active is a minimum.

7. A glow discharge device comprising a vessel, a gaseous medium therein, a dome-shaped cathode adjacent one end of said vessel, an anode coaxial therewith and positioned below said cathode, said cathode having an electron emitting coating on the surface directed toward the end of said vessel, and a probe extension on said anode mounted parallel to the side of said cathode and reaching to a position adjacent the apex of said dome-shaped cathode, whereby a glow discharge simultaneously occurs between said cathode and anode and said probe and cathode.

8. A glow discharge device comprising a vessel containing a gaseous filling, upper and lower dome-shaped electrodes having their bases in juxtaposition, means for supporting said electrodes in said vessel, and a wire probe attached to the periphery of said lower electrode and extending along the outer surface of said upper electrode, the end thereof being adjacent the longitudinal axis of said upper electrode.

9. A glow discharge device comprising a vessel having a stem, a gaseous filling therein, a pair of similar dome-shaped electrodes having their bases in juxtaposition, parallel supports extending from each of said electrodes, an insulating spacer joined to said supports, means to support said spacer adjacent said stem, and

an arcuate extension on one of said electrodes projecting around and to a position adjacent the mid-portion of said other electrode.

10. A signal device comprising a small diameter tubular vessel having a stem and containing an ionizable gas, a pair of opposed dome-shaped electrodes positioned beyond said stem with their axes coincident with the axis of said vessel, an insulating spacer between said electrodes and said stem, a pair of supports extending from each electrode and affixed to said spacer to form a unit, conductors in said stem supporting said unit, and a probe wire connected with the electrode nearest said spacer and extending to an area adjacent the center of said other electrode.

11. A signaling device comprising a small diameter tubular vessel having a stem, an ionizable gas therein, an insulating disc mounted adjacent said stem, a cup-shaped electrode supported axially from said disc, a similar electrode

mounted in inverted relation to said first electrode and adjacent the cavity therein, said electrodes being exteriorly coated with electron emitting material and interiorly coated with non-emissive material, and an exterior curved wire attached to the lower electrode extending beyond said similar electrode and terminating closely adjacent the center of the latter electrode.

12. A glow discharge device comprising a vessel, having a stem in one end thereof, a pair of dished electrodes in said vessel supported from said stem with their bases juxtaposed, one of said electrodes having a configuration similar to that of the end of the vessel remote from the stem, and a probe electrode connected to the dished electrode adjacent the stem and extending to a point adjacent the center of the outer surface of the other dished electrode.

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